Fast Cycling SC Magnets

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Introduction

- Most high-field SC-synchrotron magnets are ramped at low dB/dt, Tevatron being one of the highest with dB/dt ~ 60-125 mT/s.
- There are also several lower field (~2T) synchrotrons which are cycled at much higher ramp-rates ~ 1-4 T/s.
  – With the exception of the Nuclotron magnets which are SC, all are resistive magnets.
- In recent plans for upgrades of accelerator facilities are proposals for higher field rapid cycling SC magnets, 2-4T

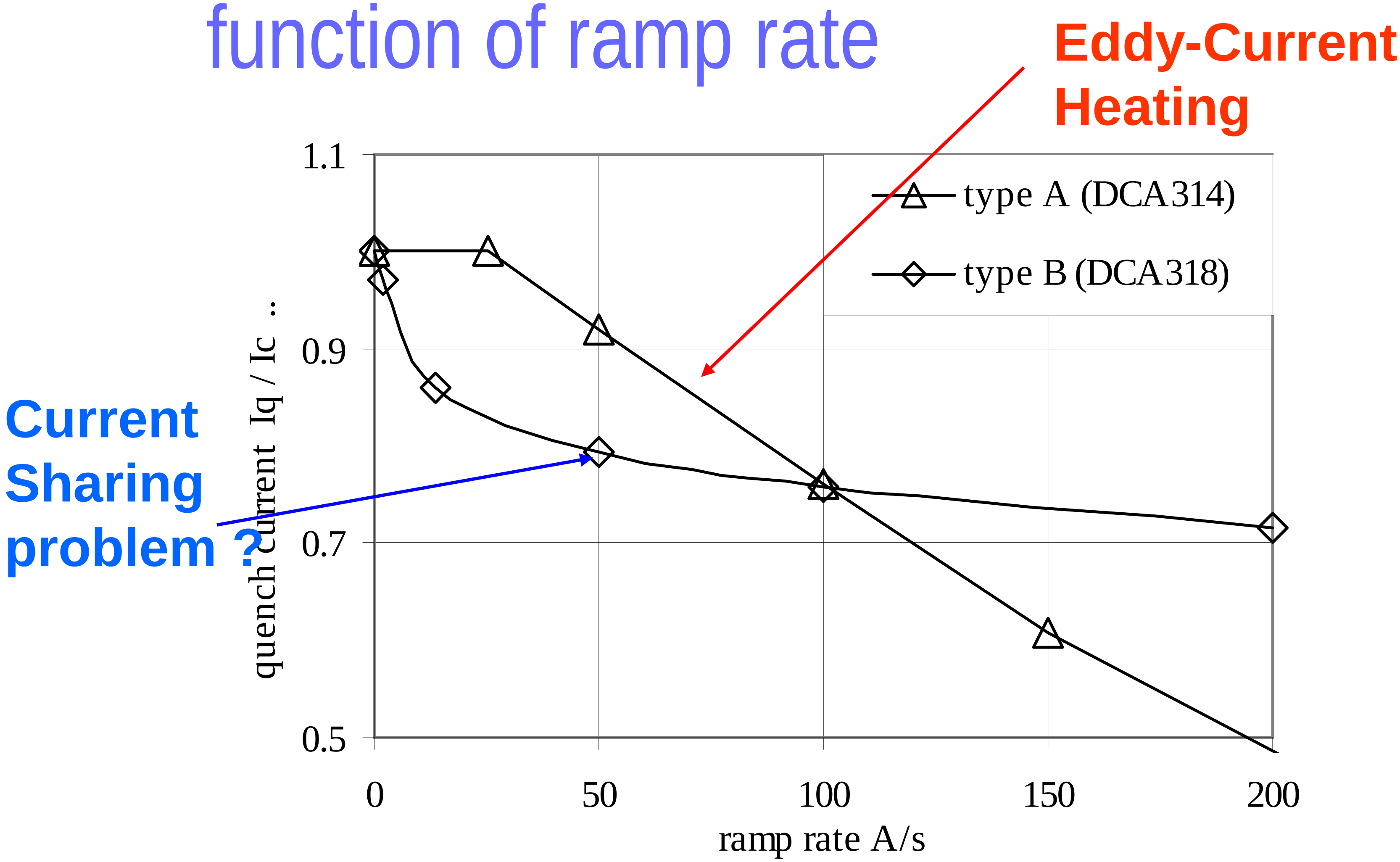
2-4T Rapid Cycling Magnets

- GSI has proposed, as part of their facility upgrade, using SC magnets in the range of 2-4T cycling at 4 T/s.

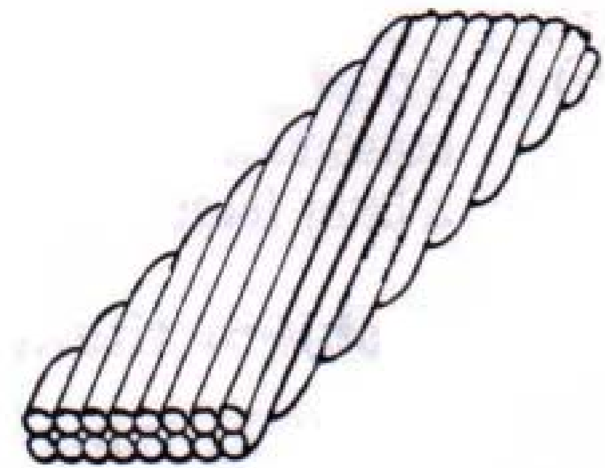
Fast Pulsed Magnets operated at 4T/s

- Technical Challenge:
  - Minimize losses due to eddy currents
    - In Strand, Cable, Iron, Beam tube
  - Reduce losses due to SC magnetization and the iron
  - *Avoid Ramp rate induced quenching found in some fusion magnets and investigated in detail during the development of magnets for the SSC High Energy Booster*
  - Develop precise magnetic field measurement system for fast-changing magnetic fields

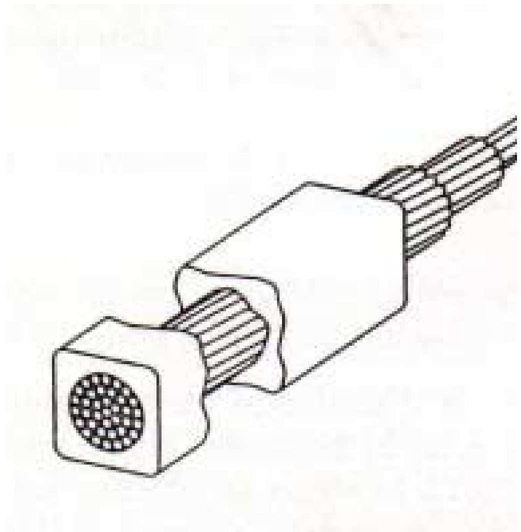
Quench current of SSC magnets as a function of ramp rate



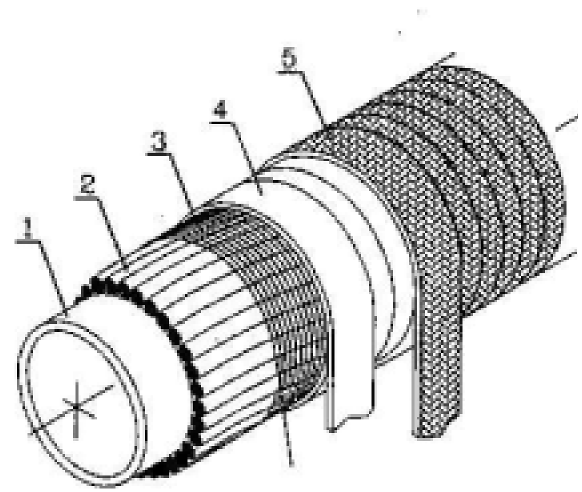
Conductor/ Cable Design



Rutherford



CICC



Nuclotron

1-Cooling tube

2- Sc. strands

3- Nichrome wire

4- Kapton tape

5 Glassfiber tape

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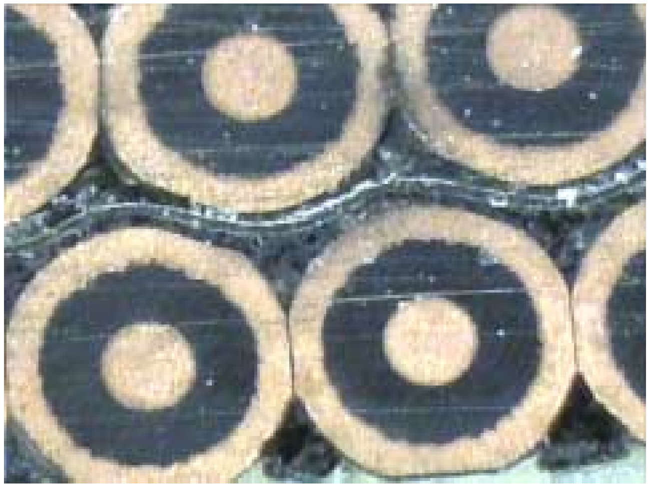
Strand Design

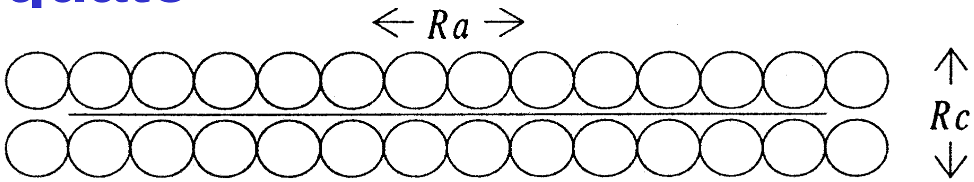
- Minimize SC magnetization
  - Small filament diameter 1-5 μm
- Small eddy-current loss
  - High-resistive matrix
  - Small twist pitch
- And still have a high Jc

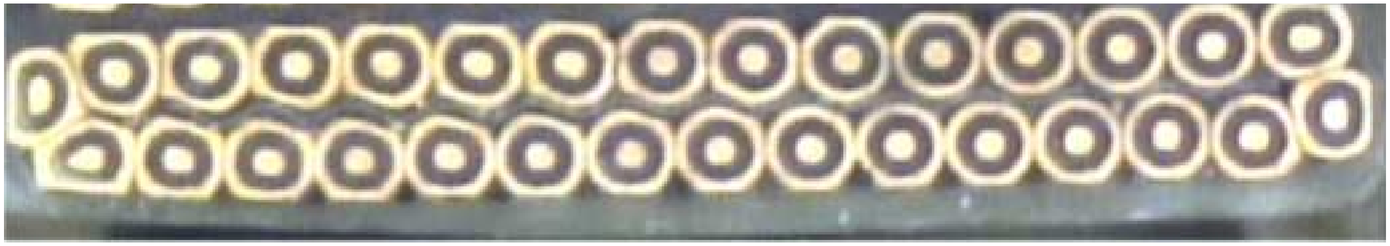
RHIC strand 6 μm filaments, Cu-matrix

Cable loss in a Rutherford Cable

- **Cable loss** controlled by resistance of
  - Crossing wires, $\mathbf{R_C}$
  - Adjacent wires, $\mathbf{R_A}$
- **Reduce R_c Loss**
  - **Resistive core**
- **Maintain R_A for adequate Current Sharing**

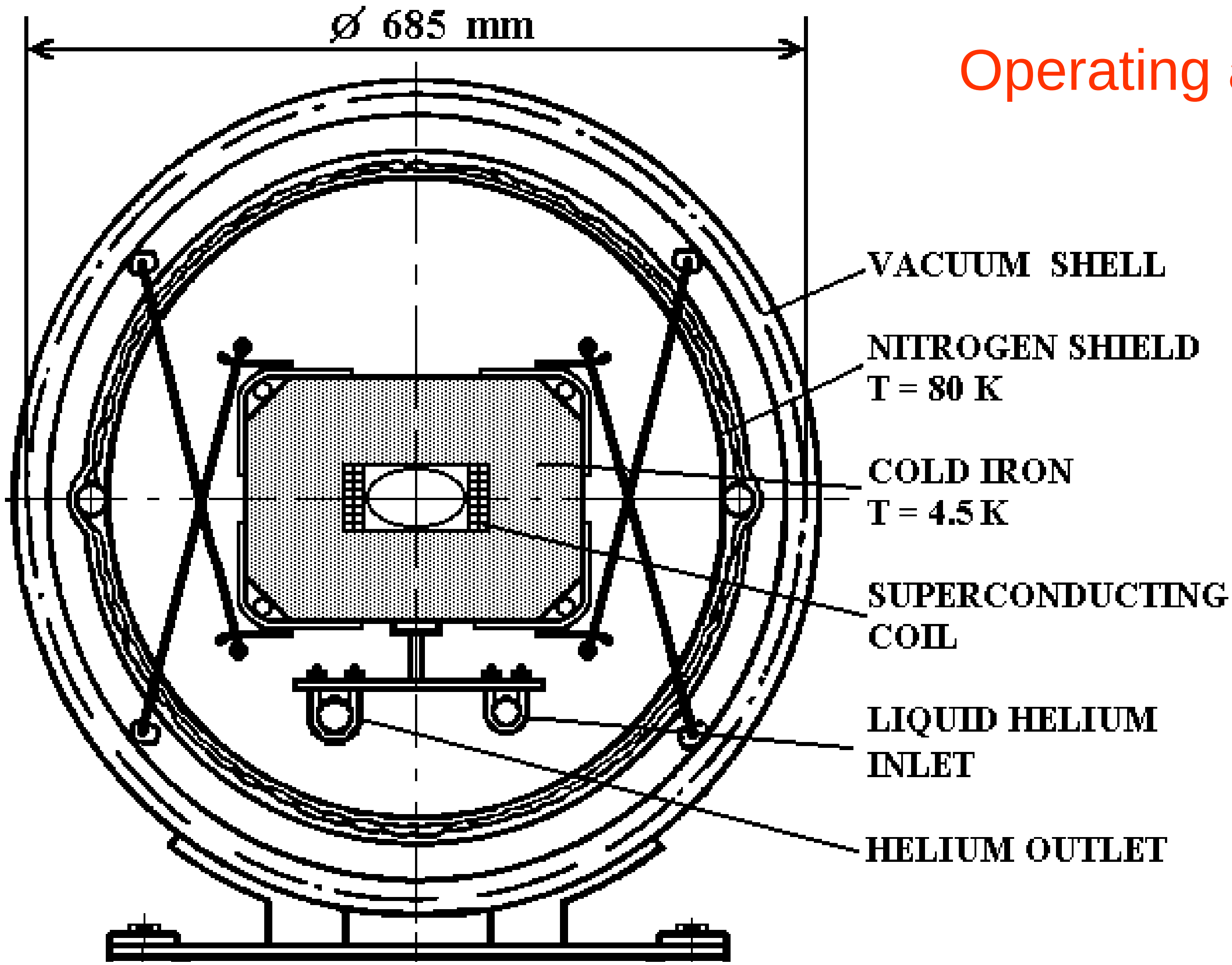






2T Super-ferric Magnet (Nuclotron)

Operating at 4T/s



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Prototype Cos θ 4T Magnet

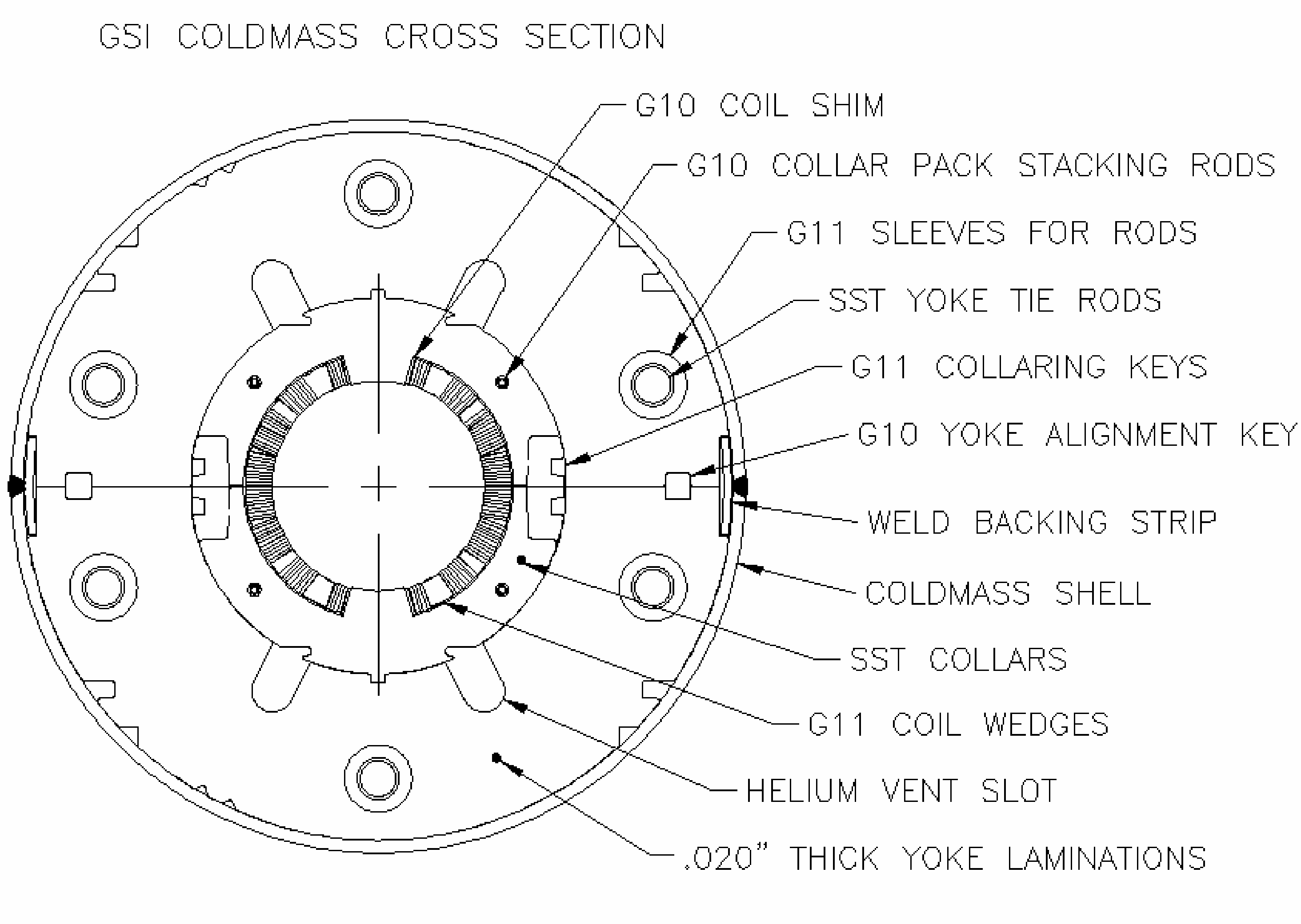
Cable with core

RHIC coil with G11 wedges

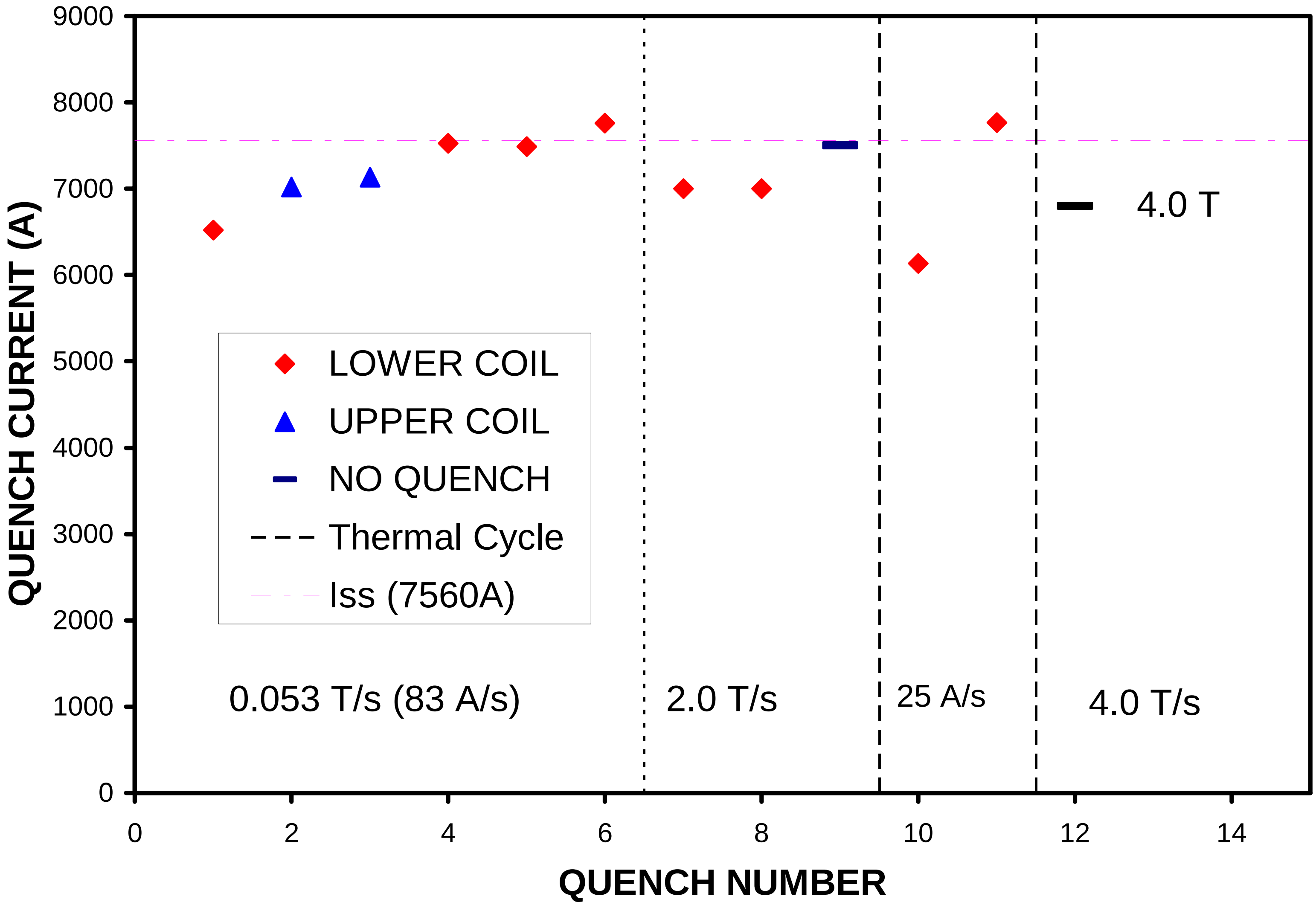
SS collars

G11 collar keys

0.5 mm Si-steel yoke lamination



GSI-001 Quench Performance



Workshop Plans

- Issues for SC magnets operating at 1Hz
  - Optimal conductor choice
  - Warm or cold iron
  - Maximum field range ? (SIS 300 ⇨ 6T)
  - Effect of Cyclical Stress in the Coil
  - Field Harmonic measurements
- Issues for SC magnets operating in the 5-10 Hz range
  - Conductor design (more like AC wires and cables)
  - Operating field (iron or coil dominated magnets)
- Present Status